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Wetting of Nano-patterned Silicon Surfaces by of Hydrocarbon Vapor

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Beamline(s): X22A

Introduction: Nano-patterned surfaces are potentially attractive for the broad range of technologies, i.e. design of chemical and biological chips, microfluid devices and electronic applications [1]. They are also a great interest of statistical mechanics due to the crossover between capillary condensation and wetting phenomenon that considerably enriches wetting phase diagram and surface film structures [2].

Methods and Materials. The nearly hexagonal nano-pattern (AFM picture, Fig. 1), consisting of pits that are about 200 Å wide by <80 Å deep, was created using self-organized diblock copolymer [3]. Grazing incident diffraction (Fig. 2) detects two peaks, at wavevectors parallel to the surface q_{xy}=0.017 Å^{-1} and q_{xy}=0.029 Å^{-1}. These correspond to d-spacings of d_{11}=376 Å and d_{20}=216 Å of relatively weak 2D long-range hexagonal order with an average lattice constant ~434 Å^{-1}. We studied the wetting of the nano-patterned silicon surface by a hydrocarbon vapor (cyclohexane, CH). X-ray reflectivity measurements were carried out *in-situ*. The amount of adsorbed CH was controlled by changing the chemical potential [4] of CH vapor relative to its liquid reservoir through temperature differences ΔT between substrate and reservoir with accuracy <1mK.

Results: Normalized x-ray reflectivity (R/R_F) from the dry nano-pattern silicon surfaces, taken in an nitrogen atmosphere (Fig. 3, "Dry"), has two distinct minima at q_z=0.06 Å^{-1} and at q_z=0.39 Å^{-1}. We attribute them respectively to the pit depth and the hydrocarbon monolayer, naturally adsorbed on the chemically clean silicon surfaces. Introducing of the cyclohexane vapor leads to the gradual shift of the "hydrocarbon" minimum due to adsorption of CH on the silicon surface. The contrast decrease of the low-q_z minimum is interpreted as a filling of the pits with cyclohexane.

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References:

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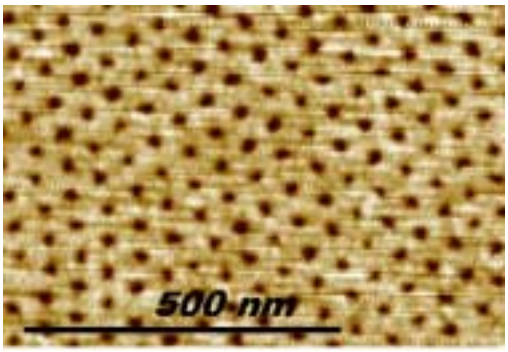
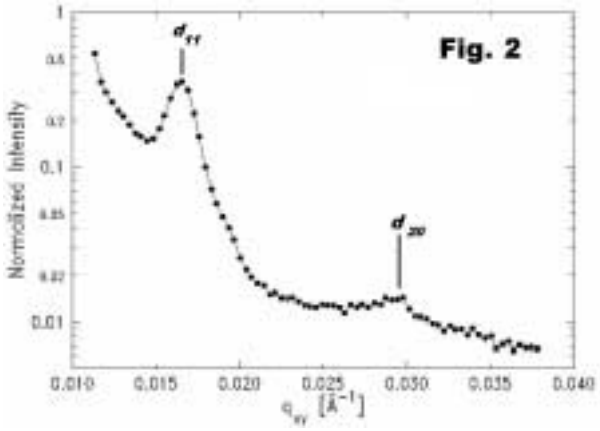


Fig. 1



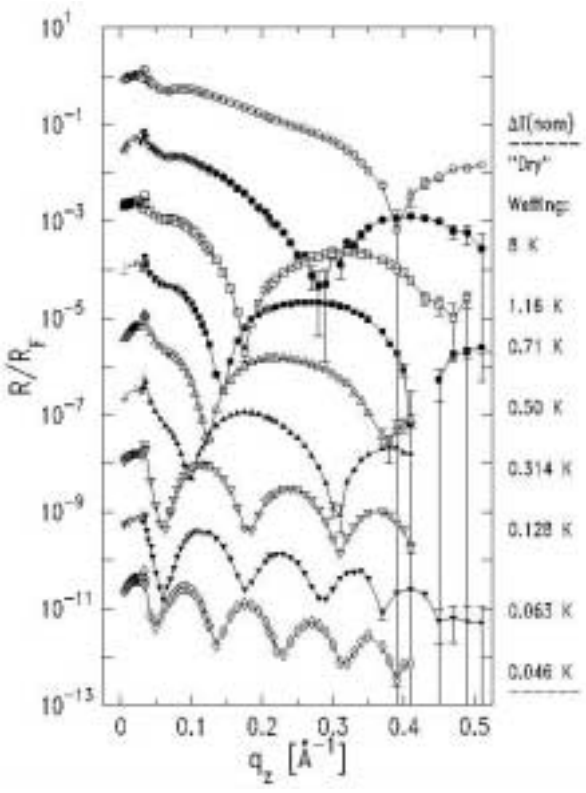


Fig. 3